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ABSTRACT

The overall objective of this project was to develop a training program and materials for power plant training in North Dakota. The project utilized four separate instructional units and four separate enrollment times with eight students enrolling in each phase to a maximum of thirty-two students. The course that resulted from the project is comprised of five units. The first unit of instruction deals with a basic power plant orientation, including all the basic subjects, i.e., introduction, basic subjects, print reading, auxiliary equipment, and meters and instruments. The second unit includes all auxiliary equipment, such as piping systems, valves, traps, pumps, feedwater heaters, and water treatment. The third unit, Boilers, and Auxiliaries, is comprised of types of boilers, boiler components, boiler accessories, steam generation, thermodynamic cycles, fuels--fossil, combustion, instrumentation, controls, procedures for operation, and cleaning. Unit 4 focuses on generator and electrical systems. The fifth unit, Turbines and Auxiliaries, includes steam turbines, mechanical drives, condenser circulating water, condensate systems, and gas turbines. (A course outline is appended.) (LRA)

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POWER AND ENERGY SYSTEMS TECHNOLOGY PROGRAM

Research Series No. 43

Conducted by Vocational Education Department

Bismarck Junior College
Bismarck, North Dakota 58501

Project Director: Mr. Harvey Haakenson
Vocational Director

June, 1977

U S DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

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POWER AND ENERGY SYSTEMS TECHNOLOGY PROGRAM

BACKGROUND OF PROJECT

The project conducted under this study was determined to be necessary as a result of the increased demand for coal related energy occupations in the state of North Dakota. There were a number of state and private agencies which cooperated in the developmental phase of the project and who were instrumental in providing funds. The overall project to develop a technology program was funded under Part D of the Vocational Education Act. Implementation of the program activities, once developed, was conducted under the regular program B monies. The secondary grant to develop a training program and experimental site for coal related energy opportunities for North Dakota personnel was provided under the Old West Trail Commission's funding. The initial activity began with the Old West Trail Commission's project to identify opportunities available in the state of North Dakota for persons interested in working in energy related occupations. The project identified various occupations and established task analyses for these related occupations. One of the occupations identified was in the area of technologist for power energy systems.

The State Board for Vocational Education funded Bismarck Junior College to conduct a study for the purpose of developing a curriculum for power and energy systems technology. The program was to begin with a limited number of students and one instructor for the purpose of developing usable material initially and testing those materials with a small number of students. Once the initial

phase of the project was undertaken, a second instructor would be brought aboard for the purpose of continuing the development of additional phases of the program and for instructional purposes.

PROCEDURES

To conduct a study of this nature, it was decided that an advisory committee, consisting of plant managers and other personnel in the mining and coal energy related fields, be established for the purpose of determining what the program should involve. The committee met numerous times during the course of the project and was quite instrumental in designing the direction for the course of study as developed by the two instructors. The Old West Trail Commission provided North Dakota with a grant to survey the manpower needs of expanding or emerging conversion industries utilizing North Dakota's coal and water resources. The results of this survey indicated a need of 700 additional personnel by 1981 in plant operation occupations. The advisory committee used the data provided from the survey to develop what they felt were the needed guidelines to meet the needs of the expanding industries.

To conduct the study and to house the students it was felt that a suitable laboratory must be established. A 40 feet by 50 feet area adjacent to Bismarck Junior College Intensified Training Center was leased for the purposes of this study. A classroom used by the Intensified Training Center was shared as a center for the students as they came into the program.

Because the advisory committee was comprised of members of the plant management, it was a logical step to involve these people very heavily in the identification of necessary training equipment. Once the committee had established the proper equipment for the

for the purpose of conducting the training programs, this equipment was purchased from various sources throughout the nation. Because of the uniqueness of the equipment, it was difficult to obtain. A great amount of lead time was necessary from date of purchase to acquisition of the equipment into the laboratory setting. While there were some delays in obtaining equipment, there were no major conflicts in the establishment of the training program and the implementation of training necessary for the students.

RESULTS

The overall objective of the project was to develop a training program and materials for power plant training in the state of North Dakota at the post-secondary level. The specific objectives of the project were: 1) to develop an overall curriculum and daily lesson plan for students in usable format, 2) to purchase the necessary laboratory equipment and to develop hardware assuring the proper use of the laboratory equipment, 3) to initiate the program with eight students, 4) to add an additional eight students three months after the first eight students were on board, 5) to add an additional eight students to the existing 16 students in the program, 6) to add a final eight students to the existing 24 students three months after the third phase of the program, 7) after all the instructional material was developed and field tested with the students it was to be revised as agreed to by the advisory committee and the instructors.

The project called for four separate instructional units and four separate enrollment times with eight students enrolling in each phase to a maximum of thirty-two students. The final group of eight students were enrolled during the month of June for the

fourth and final phase of the curriculum program. On completion of all four phases the initial eight students would be ready for employment in the field of power and energy systems.

As Unit I of the project was being completed and Unit II involving an additional eight students was being implemented, the curriculum materials utilized in Unit I were being revised. During the course of instruction in Unit I, the curriculum materials for Unit II were being developed. Therefore, the instructional load consisted also of a field test and developmental work along with the actual course instruction beginning with the first eight students enrolled in the program. The instructor developed course materials during Phase I without any students in attendance. Phase II involved the instruction of the materials developed in Phase I and the development of materials for Unit II. The second instructor became a necessity as a result of the demand for instructors time in both development and instructional along with planning purposes. The third phase involved development, instruction, and revision of materials taught in the prior phase.

Course Description:

The program was broken down into four major units of instruction: Boilers and Auxiliaries; Turbines and Auxiliaries; Peripheral Equipment and Systems; and Generators and Electrical. There was no preferred sequence for developing one unit before the other. Rather, this was the result of the availability of equipment more so than a sequencing for educational purposes. An orientation unit in addition to the four major units was developed also for the purpose

of familiarizing all students with the power generation industry. All students, prior to attending the courses for major units, were exposed to the orientation unit.

The rational for accepting eight students only at the beginning of each unit was that the low student-teacher ratio would allow sufficient time for the instructors to develop the necessary material for additional course work. It would also allow a greater number of hours with individual student, which was considered necessary due to the experimental nature of the program. A second reason for enrolling students in limited numbers four times during the year was that it provided a more equitable distribution of personnel available to the industry. Rather than graduating 32 students at any one time during the year, it was possible for each student to have been completely trained in the system and to graduate at alternate times during the year thereby providing a more logical sequencing into the area of work as needed by industry through attrition and other related hiring policies.

The appendix of this report includes a list of the five units that were developed with the respective courses that were developed as a component of those units. Unit I - Orientation has five separate units; Unit II - Auxiliary Equipment and Systems has 24 separate units; Unit III - Boilers and Auxiliary has 15 separate units; Unit IV - Turbines and Generator Auxiliaries has 8 units; and Unit V - Generator and Electrical Systems has 12 separate units.

The power and energy systems technology course was designed to cover 12 months of instruction involving five separate units of instruction. The units are arranged so that students may be enrolled or graduated on a staggered basis, enrolling and/or graduating eight students every 12 weeks during the year. A more complete description of the course of study follows:

The first unit of instruction deals with a Basic Power Plant Orientation PPT-100 including all the basic subjects, ie. Introduction, Basic Subjects, Print Reading, Auxiliary Equipment, and Meters and Instruments. The orientation unit is four weeks in duration. (All students take this unit before progressing to any other unit.)

The second unit (Auxiliary Equipment and Systems PPT-200) is twelve weeks in length and includes all Auxiliary Equipment such as, Piping Systems, Valves, Traps, Pumps, Feedwater Heaters, Water Treatment, Demineralizers and Softners, Instruments, Air Compressors, Fire Fighting Systems, Oil Storage, Coal Handling, Ash Disposal, and Lubrication.

The third unit (Boilers and Auxiliaries PPT-300) is twelve weeks and consists of: Types of Boilers, Boiler Components, Boiler Accessories, Steam Generation, Thermodynamic Cycles, Fuels-fossil, Combustion, Instrumentation, Controls, Procedures for Operation, and Cleaning.

Unit number four (Generator and Electrical Systems PPT-400) is complimentary to Basic Electricity taught in unit one. This unit consists of: D C Systems, Generators and Exciters, Trans-

formers, Station Service, Insulation, Insulating Material, Transmission, Auxiliary Electrical Equipment, Meters and Instruments, etc.

The fifth unit (Turbines and Auxiliaries PPT-500) includes, Steam Turbines, Mechanical Drives, Condenser Circulating Water, Condensate Systems, and Gas Turbines.

The course is arranged so that the student spends part of the time in a classroom for theory and part of the time in a shop lab where he may apply the theory taught. The shop lab is located adjacent to the classroom for this purpose. Simulators and other actual equipment were installed to form a realistic plant.

Students operate the equipment following the procedures recommended by the instructor/manufacturer of the equipment. Students act as shift personnel and are required to read meters and record on operating log sheets, temperatures, pressures, levels, etc. Students also act as maintenance personnel making adjustments on equipment and cleaning and maintaining the plant in whatever manner may be required.

The students are also taught to solder and braze. They are instructed in the proper use of hand tools utilized in a power plant as a regular component of their instructional package.

BENEFITS

The overall benefit of the program as conducted by Bismarck Junior College was the implementation of a training program in

power plant technology. Industry has asked for a program of this nature for a number of years. The survey conducted as a result of the Old West Trail Commission project pointed out in vivid detail the necessity for a training program of this nature. The program is unique in that it does not flood the market at any one time during the school year with graduates from the program. The staggered entrance and exit of students in a four cycle educational course allows industry to accept students consistent with the normal flow of management and hiring policies. The overall benefit to the state of North Dakota is that the power plant industry will have an exceptionally well trained staff of personnel to go on line when the new power plants begin operation in 1979-1980.

The students graduating from the power and energy systems technology program through Bismarck Junior College will begin their occupational choice at the normal entrance level within the power plants. Because of the training that they have received in the course they will be able to advance much more rapidly within the existing power plant structure. As each power plant is a separate and unique operation, each student must begin at a common level of employment. The advancement through the ranks to management will be attained much more easily and much more rapidly due to the program of study provided at Bismarck Junior College.

An additional benefit derived from this project was to further the concept of a multi-course instruction for technology courses. The five step approach utilized in this project will be utilized in future curriculum development activities in the technology industries.

ADDITIONAL INFORMATION

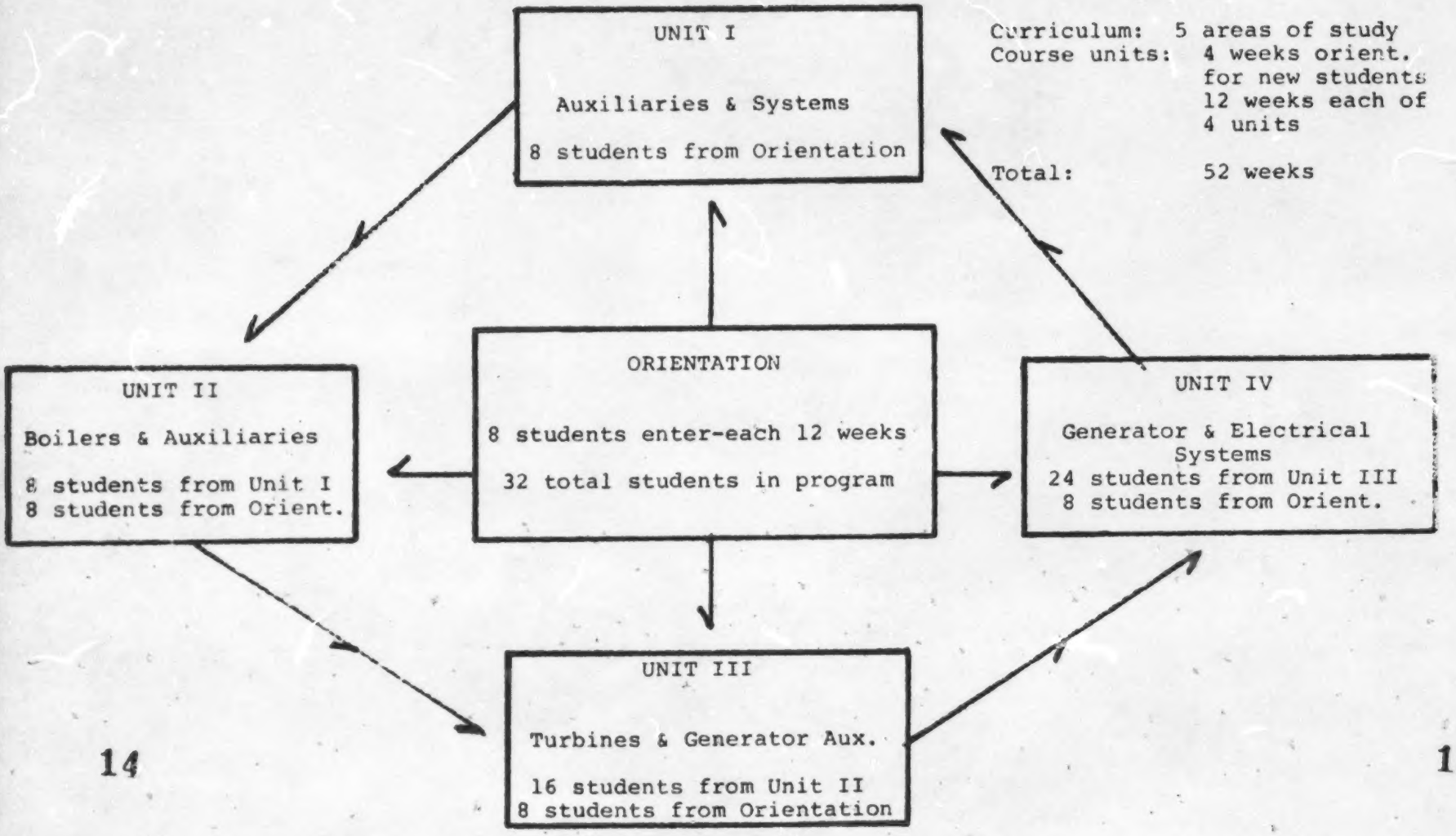
A person requiring additional information about the power and energy systems technology program may contact the following person at Bismarck Junior College: Mr. Harvey Haakenson, Vocational Director, Bismarck Junior College, Bismarck, North Dakota 58501.

Copies of the final report are available through the ERIC System and through the Research Coordinating Unit Network in the nation. Additional copies in limited number will be available from the North Dakota Research Coordinating Unit, State Office Building, 900 East Boulevard, Bismarck, North Dakota 58505.

The materials used in the curriculum component of the project were taken extensively from materials provided by Southern Alberta Institute of Technology, Calgary, Alberta, Canada. Sincere appreciation for the use of these materials is extended to Southern Alberta Institute of Technology.

APPENDIX A

FIRST YEAR OF OPERATION



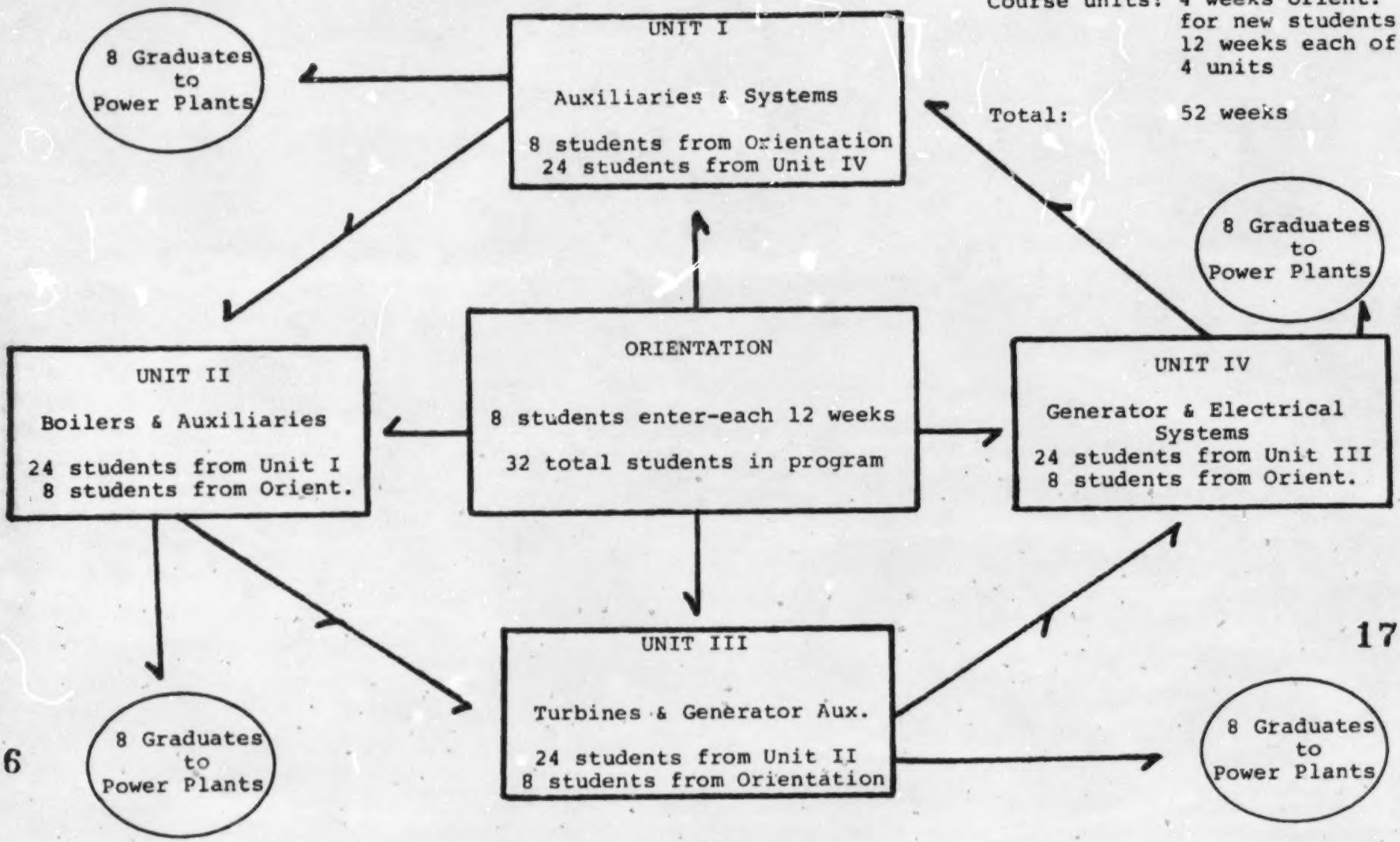
Curriculum: 5 areas of study
Course units: 4 weeks orient. for new students
12 weeks each of 4 units

Total: 52 weeks

SECOND YEAR OF OPERATION

Curriculum: 5 areas of study
Course units: 4 weeks orient. for new students
12 weeks each of 4 units

Total: 52 weeks



APPENDIX B

COURSE DESCRIPTION

POWER PLANT TECHNOLOGY

ORIENTATION

PPT-100

PPT 101 POWER PLANT INTRODUCTION

A. Introduction
   1. Supervisors
   2. Description and tour of plant
B. Orientation
   1. Student generating plant operator training program
   2. Labor-management relations
   3. Public relations
   4. Employee status and benefits
C. Safety
   1. Safety manual
   2. Safety practices and equipment
D. Fire Protection
   1. Fire prevention
   2. Fire fighting
E. First Aid Course
F. Tools and Fastners

PPT 102 POWER PLANT BASICS

A. Units of Measurement
   1. English
   2. Metric
B. Mechanics
   1. Machines and friction
C. Properties of Matter
   1. Matter and molecular motion
   2. Behavior of matter when in motion
D. Basic Heat and Steam
   1. Heat transfer, evaporation and condensation
E. Water Treatment
F. Basic Electricity
   1. Symbols
   2. Flow diagrams
   3. Control diagrams
   4. Logic diagrams

PPT 103 PRINT READING

A. Mechanical Prints
   1. Symbols
   2. Flow diagrams
   3. Control diagrams
   4. Logic diagrams

B. Electrical Prints
   1. Symbols
   2. Single line
   3. Schematics

PPT 104 AUXILIARY EQUIPMENT

A. Fire-Fighting Systems
   1. Outside
   2. High-pressure
   3. Sprinkler
   4. Carbon Dioxide

PPT 105 METERS AND INSTRUMENTS

A. Indicating
B. Integrating
C. Recording
D. Oscillograph
E. Flow
   1. Differential
   2. Volumetric
F. Liquid Level
   1. Float
   2. Differential pressure
G. Pressure
   1. Bourdon type
   2. Bell and diaphragm
   3. Manometer
   4. Barometer
H. Temperature
   1. Thermometer
   2. Thermocouple
   3. Resistance
   4. Gas-actuated
   5. Pyrometer

AUXILIARY EQUIPMENT

PPT-200

PPT 201 Piping Systems

1. Piping materials
2. Supports and fittings
3. Fluid loss
4. Insulation

PPT 202 Valves

1. Types
2. Construction
3. Applications

PPT 203 Drain Traps

1. Types
2. Construction
3. Principles of operation
4. Application

PPT 204 Pumps

1. Types
2. Construction
3. Operation

PPT 205 Condensate System (pt I)

1. Condensers
2. Evaporators
3. Heaters

PPT 206 Condensate System (ppt II)

1. Pumps
   a. Condensate systems
   b. Feed water systems
2. Valves & Piping
   a. Condensate
   b. Feed water
3. Drains & Heaters
   a. High-pressure
   b. Low pressure

PPT 207 Condensate System (pt III)

1. Water treatment
   a. Condensate
   b. Feed Water
2. Deaerator systems

PPT 208 Feedwater Heaters

1. Types
2. Construction
3. Operation

PPT 209 Makeup Water System

1. Filter plant
2. Demineralizers
   a. Operation
   b. Regeneration
3. Water storage & transfer
4. Caustic
   a. Storage
   b. Handling
   c. Hazards & precautions
5. Acid
   a. Storage
   b. Handling
   c. Hazards & precautions

PPT 210 Secondary Feedwater Treatment

1. Principles & purpose
2. Chemicals
3. Pumps

PPT 211 Demineralizers & Softeners

1. Construction
2. Operation
3. Applications

PPT 212 Air Removal Equipment

1. Types
2. Construction
3. Operation

PPT 213 Cooling Towers

1. Construction
2. Principle of operation
3. Chemical treatment

PPT 214 Instruments

1. Flow
   a. Differential
   b. Volumetric

PPT 214 Instruments (cont.)

2. Liquid level
   a. Float
   b. Differential pressure
3. Pressure
   a. Bourdon type
   b. Bell & diaphragm
   c. Manometer
   d. Barometer
4. Temperature
   a. Thermometer
   b. Thermocouple
   c. Resistance
   d. Gas-actuated
   e. Pyrometer

PPT 215 Air Compressors & Compressed Systems

1. Type of compressors
2. Construction
3. Filters
4. Dryers
5. Coolers
6. Receivers
7. Systems
   a. Control air
   b. Station service air
   c. Seal air
   d. Aspiration air
   e. Soot-blowing air
8. Drains & piping
9. Controls

PPT 216 Raw Service - Raw Cooling Water

1. Pumps
2. Valves and piping
3. Controls
4. Operation

PPT 217 Fire-Fighting Systems

1. Outside
2. High-pressure
3. Sprinkler
4. Carbon dioxide

PPT 218 Oil Storage, Transfer & Purification

1. Turbine lubrication & hydraulic oil
   a. Transfer pumps & piping
   b. Oil purification equipment

PPT 218 Oil Storage, Transfer & Purification (cont.)

2. Fuel oil system
   a. Storage
   b. Pumps and piping
   c. Operation

PPT 219 Coal Handling

1. Unloading facilities
2. Coal belt conveyor system
3. Coal preparation equipment
4. Coal sampling
5. Storing & reclaiming

PPT 220 Ash Disposal System

1. Bottom ash
2. Fly ash
3. Pyrite
4. Pumps, valves and piping
5. Controls and operation

PPT 221 Miscellaneous Equipment

1. Filters
2. Strainers
3. Drive components
4. Air conditioning

PPT 222 Miscellaneous Systems

1. Gland seal water
   a. Pumps
   b. Tanks
   c. Controls
2. Injection water
   a. Pumps
   b. Controls
3. Vacuum priming
   a. Pumps
   b. Valves and piping
   c. Controls

PPT 223 Heating, Ventilation & Air-conditioning Systems

1. Building heating systems
   a. Boilers
   b. Heat exchangers
   c. Valves, piping and drains
   d. Controls and operation
2. Building air-conditioning systems
   a. Chillers
   b. Valves and piping
   c. Controls and operation

OPT 224 Lubricants, Lubrication, and Bearings

1. Principles of lubrication
2. Types of lubricants
3. Lubricating schedules
4. Bearings

BOILERS AND AUXILIARIES

PPT-300

PPT 301 Types

1. Fire tube
2. Water tube

PPT 302 Water Tube Boilers

1. Pressure
2. Methods of circulation
3. Fuel
4. Firing methods
5. Ash disposal
6. Draft

PPT 303 Boiler Components

1. Drum and internals
2. Walls
   a. Tubes
   b. Headers
   c. Insulation
3. Casing
4. Bottoms
5. Economizers
6. Superheaters
7. Reheaters
8. Baffles
9. Ducts
10. Burners, burner boxes, windbox and air registers
11. Dampers
    a. Types
    b. Construction
    c. Operation and control
12. Fans
    a. Types
    b. Construction
    c. Operation and control
13. Doors and other openings
14. Air preheaters
15. Stacks

PPT 304 Boiler Accessories

1. Safeties
2. Other pressure control devices
   a. Power relief valves
   b. Superheater bypass valves
   c. Turbine bypass valves
   d. Reheat bypass valves
3. Boiler blowdown valves and drains systems
4. Water columns, gauge glasses and level indicators
5. Vents

PPT 305 Steam Generation

1. Theory
2. Water system separation
3. Circulation
   a. Natural
   b. Forced

PPT 306 Thermodynamic Cycles

1. Reheat cycle
2. Regenerative cycle
3. Heat balance
4. Efficiency

PPT 307 Fuels - Fossils

1. Coal
2. Gas
3. Oil

PPT 308 Combustion of Fuels

1. Combustion chemistry
2. Fuel/air relationships
3. Determining combustion efficiency

PPT 309 Fuel Systems

1. Pulverized fuel
   a. Pulverizers
   b. Feeders
   c. Fans
   d. Scales
   e. Dampers
   f. Bunkers and pipes
   g. Burners
2. Cyclone furnace
   a. Coal preparation
   b. Principle of operation
   c. Feeder construction and operation
3. Gas
   a. Burners
   b. Regulators

PPT 310 Soot and Slag Blowing

1. Types of blowers
2. Blowing mediums
3. Control

PPT 311 Fly Ash Removal

1. Mechanical separators
   a. Construction
   b. Principle of operation
   c. Operating procedures

PPT 312 Instrumentation

1. Types
2. Uses
3. Location

PPT 313 Controls

1. Types
   a. Pneumatic
   b. Electronic
   c. Hydraulic
2. Application
3. Boiler fuel system control
   a. Permissive relays
   b. Trip relays

PPT 314 Operating Procedures

1. Startup and shutdown procedures
2. Routine operating procedures and checks
3. Emergency operating procedures

PPT 315 Cleaning

1. Accessory steam equipment
2. Boilers and auxiliary equipment
3. Meters and instruments
4. Steam turbines and generators
5. Condensers and auxiliaries

TURBINES AND GENERATOR AUXILIARIES

PPT-400

PPT 401 Steam Turbines

1. Types
   a. Impulse
   b. Reaction
   c. Compound
   d. Cross compound
2. Blading
   a. Stationary
   b. Rotating
3. Bearings
   a. Journal
   b. Thrust
4. Valves
   a. Throttle or stop
   b. Interceptor
   c. Reheat stop
   d. Control or governor
   e. Reheat dump or ventilation
   f. Thruster or reverse current
5. Hydraulic system
6. Governing systems
   a. Mechanical governors
   b. Hydraulic governors
   c. Electronic governors
   d. Emergency governors
7. Lubrication system
8. Sealing systems
   a. Water seals
   b. Steam seals
   c. Glad seal exhausters
9. Sealing steam
   a. Valves and piping
   b. Control
10. Jacking devices
11. Instrumentation
    a. Supervisory instruments
    b. Related temperature and pressure instrumentation
12. Turning gear

PPT 402 Generators

1. Construction
2. Cooling - rotor and stator
   a. Hydrogen
   b. Water
   c. Oil
3. Sealing system
   a. Construction
   b. Controls
4. Hydrogen supply and purging
   a. Storage
   b. Distribution and regulation
   c. Generator purging procedures
5. Carbon dioxide supply system
   a. Storage
   b. Distribution and regulation
6. Operating procedures
   a. Startup and shutdown
   b. Normal operating procedures and inspections
   c. Emergency operating procedures
7. Instrumentation

PPT 403 Mechanical Drive Turbines

1. Governor
2. Extraction points
3. Backpressure regulator
4. Sealing
5. Lubrication
6. Hydraulic systems
7. Operation
8. Vibration

PPT 404 Condenser Circulating Water

1. Intake structure
2. Pumps
3. Tunnels
4. Chlorination
5. Valves

PPT 405 Condensate System

1. Pumps
2. Demineralizer polishing equipment
3. Low-pressure heaters and drains
4. Recirculation system
5. Makeup and dump-back system and control
6. Deaerator

PPT 406 Feed-Water System

1. Pumps-construction and operation
   a. Feedwater pumps
   b. Booster pumps
2. High-pressure heaters and drains
3. Valves and piping

PPT 407 Gas Turbines

1. Peaking
2. Total energy
3. Emergency, cold cranking
4. Combined cycle

GENERATOR AND ELECTRICAL SYSTEMS

PPT-500

PPT 501 Direct Current Systems

A. Batteries
B. Busses
C. Connections
D. Protection
E. Charging Equipment
F. Electrical Drawings

PPT 502 Generators and Exciters

A. Construction
B. Operation
C. Excitation
D. Voltage regulation
E. Protective devices
F. Temperature limits
G. Electrical drawings

PPT 503 Transformers

A. Theory
B. Types
C. Connections
D. Application
E. Cooling methods and systems
F. Protection
G. Electrical drawings

PPT 504 Station Service

A. Transformers
B. Station busses and feeders
C. Boards
D. Normal and emergency feeds
E. Air circuit breaker operation
F. Automatic transfers
G. Protection
H. Electrical drawings

PPT 505 Inverters

A. Theory
B. Types
C. Application

PPT 506 Insulating Materials

A. Different classes
B. Temperature limits of each
C. Where different types are used
D. Temperature limits on each application

PPT 507 Transmission Substation

A. Disconnecting switches
B. Oil circuit breakers
C. Pneumatic circuit breakers
D. System connection
E. Electrical drawings

PPT 508 Auxiliary Electrical Equipment

A. Grounding system
B. Fuse
C. Relays
   1. Generator
   2. Transformer
   3. Busses
   4. Station auxiliaries

PPT 509 Meters and Instruments

A. Indicating
B. Integrating
C. Recording
D. Oscillograph

PPT 510 General Inspection of

A. Bus compartments
B. Station service equipment
C. Transformer yard
D. Switchyard
E. Boards

PPT 511 Miscellaneous Equipment

A. Signal system
   1. Code call
   2. Fire arms
   3. Public address system

PPT 512 Cleaning

A. Switchboards
B. Relay boards
C. Rotating machinery